

CLAIMS

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1. A method of determining a respective process value of at least one input variable governing a plasma process sequence for creating a desired surface profile on a process substrate, the method comprising the steps of:
 4. a. selecting a respective test value of the at least one input variable;
 5. b. subjecting a test substrate to a test process defined by the respective test value, thereby creating a test surface profile;
 6. c. providing an initial surface profile model in terms of the at least one input variable and at least one unknown coefficient;
 7. d. generating an approximate profile prediction from the initial surface profile model and the respective test value of the at least one input variable;
 8. e. generating an indicator of difference between the test surface profile and the approximate profile prediction;
 9. f. generating a respective optimum value of the at least one unknown coefficient that minimizes the indicator of difference;
 10. g. modifying the initial surface profile model to include the at least one optimum value, thereby providing a final model in terms of the at least one input variable; and
 11. h. generating the respective process value of the at least one input variable from the final model and the desired surface profile.

- 1 2. The method of claim 1 wherein the at least one unknown coefficient comprises a plurality of unknown coefficients.
- 1 3. The method of claim 1 wherein the at least one input variable comprises a plurality of input variables, the approximate profile prediction being generated from the initial surface profile model and the respective test values of each of the plurality of input variables.

1 4. The method of claim 1 wherein the test surface profile comprises a plurality of
2 snapshots, the approximate profile prediction including a frame corresponding to each
3 snapshot, the step of generating an indicator of difference between the test surface profile
4 and the approximate profile prediction including pairwise comparison of each snapshot
5 with the respective corresponding frame.

1 5. The method of claim 1 wherein generating an approximate profile prediction includes
2 using a respective rough preliminary value of the at least one unknown coefficient.

Sub a2

1 6. The method of claim 35 wherein generating a respective optimum value of the at least
2 one unknown coefficient includes changing at least one of said at least one respective
3 rough preliminary value of the at least one unknown coefficient and comparing the test
4 surface profile and the approximate profile prediction incorporating the at least one
5 changed value.

1 7. The method of claim 1 wherein the indicator of difference is generated by a
2 multidimensional nonlinear least-squares technique.

1 8. A method of processing a process substrate to create a desired surface profile thereon,
2 the process comprising the step of applying a plasma process to the process substrate, the
3 plasma process being defined by the respective process value of the at least one input
4 variable determined by the method of claim 1.

Sub a3

1 9. A device made by processing a process substrate as defined in claim 4.

Sub a3

1 10. A method of predictively calculating a process surface profile to be created on a
2 process substrate by a plasma process sequence defined by a respective process value of
3 at least one input variable, the method comprising the steps of:

4 a. selecting a respective test value of the at least one input variable, at least one of
5 said at least one respective test value being unequal to at least one of said at least one
6 respective process value;
7 b. subjecting a test substrate to a test process defined by the respective test value,
8 thereby creating a test surface profile;
9 c. providing an initial surface profile model in terms of the at least one input
10 variable and at least one unknown coefficient;
11 d. generating an approximate profile prediction from the initial surface profile
12 model and the respective test value of the at least one input variable;
13 e. generating an indicator of difference between the test surface profile and the
14 approximate profile prediction;
15 f. generating a respective optimum value of the at least one unknown coefficient
16 that minimizes the indicator of difference;
17 g. modifying the initial surface profile model to include the at least one optimum
18 value, thereby providing a final model in terms of the at least one input variable; and
19 h. introducing the respective process value of the at least one input variable into
20 the final model, thereby forming a description of the process surface profile.

1 11. The method of claim 10 wherein the at least one unknown coefficient comprises a
2 plurality of unknown coefficients.

1 12. The method of claim 10 wherein the at least one input variable comprises a plurality
2 of input variables, the approximate profile prediction being generated from the initial
3 surface profile model and the respective test values of each of the plurality of input
4 variables.

1 13. The method of claim 10 wherein the test surface profile comprises a plurality of
2 snapshots, the approximate profile description including a frame corresponding to each
3 snapshot, the step of generating an indicator of difference between the test surface profile

4 and the approximate profile description including pairwise comparison of each snapshot
5 with the respective corresponding frame.

1 14. The method of claim 10 wherein generating an approximate profile description
2 includes using a respective rough preliminary value of the at least one unknown
3 coefficient.

1 15. The method of claim 14 wherein generating a respective optimum value of the at
2 least one unknown coefficient includes changing at least one of said at least one
3 respective rough preliminary value of the at least one unknown coefficient and comparing
4 the test surface profile and the approximate profile prediction incorporating the at least
5 one changed value.

1 16. The method of claim 10 wherein the indicator of difference is generated by a
2 multidimensional nonlinear least-squares technique.

1 17. The method of claim 10 wherein the respective process value of the at least one input
2 variable varies with time.

18. A method of configuring an apparatus for processing a process substrate according to
a plasma process sequence defined by a respective process value of at least one input
variable, the apparatus including a plasma reactor, the at least one input variable
including at least one reaction variable, the method comprising the steps of:
a. selecting a respective test value of the at least one input variable;
b. subjecting a test substrate to a test process defined by the respective test value,
thereby creating a test surface profile;
c. providing an initial surface profile model in terms of the at least one input
variable and at least one unknown coefficient;

10 d. generating an approximate profile prediction from the initial surface profile
11 model and the respective test value of the at least one input variable;
12 e. generating an indicator of difference between the test surface profile and the
13 approximate profile prediction;
14 f. generating a respective optimum value of the at least one unknown coefficient
15 that minimizes the indicator of difference;
16 g. modifying the initial surface profile model to include the at least one optimum
17 value, thereby providing a final model in terms of the at least one input variable;
18 h. generating the respective process value of the at least one input variable from
19 the final model and the desired surface profile; and
20 i. configuring the reactor to process the process substrate according to the derived
21 respective process value of the at least one reaction variable.

1 19. An apparatus for determining a respective process value of at least one input variable
2 governing a plasma process sequence for creating a desired surface profile on a process
3 substrate, the apparatus comprising:
4 a. a computer memory for storing the desired surface profile;
5 b. a computer memory for storing a test surface profile, created by subjecting a
6 test substrate to a test process defined by a respective test value of the at least one input
7 variable;
8 c. means for generating an initial surface profile model in terms of the at least one
9 input variable and at least one unknown coefficient;
10 d. means for generating an approximate profile description from the initial
11 surface profile model and the respective test value of the at least one input variable;
12 e. means for generating an indicator of difference between the test surface profile
13 and the approximate profile prediction;
14 f. means for generating a respective optimum value of the at least one unknown
15 coefficient that minimizes the indicator of difference;

16 g. means for modifying the initial surface profile model to include the at least one
17 optimum value, thereby providing a final model in terms of the at least one input
18 variable; and

19 h. means for generating the respective process value of the at least one input
20 variable from the final model and the desired surface profile.

1 20. The apparatus of claim 19 wherein the test surface profile comprises a plurality of
2 snapshots, the approximate profile prediction including a frame corresponding to each
3 snapshot, the means for generating an indicator of difference between the test surface
4 profile and the approximate profile prediction being configured so as to compare each
5 snapshot with the respective corresponding frame.

1 21. The apparatus of claim 19 further comprising a computer memory for storing a
2 respective rough preliminary value of the at least one unknown coefficient, the means for
3 generating an approximate profile description from the initial surface profile model and
4 the respective test value of the at least one input variable employing the respective rough
5 preliminary value.

1 22. The method of claim 21 wherein the means for generating a respective optimum
2 value of the at least one unknown coefficient is configured to change at least one of said
3 at least one respective rough preliminary value of the at least one unknown coefficient
4 and to compare the test surface profile and the approximate profile prediction
5 incorporating the at least one changed value.

1 23. The method of claim 19 wherein the means for generating an indicator of difference
2 between the test surface profile and the approximate profile prediction employs a
3 multidimensional nonlinear least-squares technique.

Sub A5

1 24. An apparatus for predictively calculating a process surface profile to be created on a
2 process substrate by a plasma process sequence defined by a respective process value of
3 at least one input variable, the method comprising the steps of:
4 a. a computer memory for storing the respective process value;
5 b. a computer memory for storing a test surface profile, created by subjecting a
6 test substrate to a test process defined by a respective test value of the at least one input
7 variable;
8 c. means for generating an initial surface profile model in terms of the at least one
9 input variable and at least one unknown coefficient;
10 d. means for generating an approximate profile prediction from the initial model
11 and the respective test value of the at least one input variable;
12 e. means for generating an indicator of difference between the test surface profile
13 and the approximate profile prediction;
14 f. means for generating a respective optimum value of the at least one unknown
15 coefficient that minimizes the indicator of difference;
16 g. means for modifying the initial surface profile model to include the at least one
17 optimum value, thereby providing a final model in terms of the at least one input
18 variable; and
19 h. means for introducing the respective process value of the at least one input
20 variable into the final model, thereby forming a description of the process surface profile.

1 25. The apparatus of claim 24 wherein the test surface profile comprises a plurality of
2 snapshots, the approximate profile prediction including a prediction corresponding to
3 each snapshot, the means for generating an indicator of difference between the test
4 surface profile and the approximate profile prediction being configured so as to compare
5 each snapshot with the respective corresponding prediction.

1 26. The apparatus of claim 24 further comprising a computer memory for storing a
2 respective rough preliminary value of the at least one unknown coefficient, the means for

3 generating an approximate profile prediction employing the respective rough preliminary
4 value.

1 27. The method of claim 26 wherein the means for generating a respective optimum
2 value of the at least one unknown coefficient is configured to change at least one of said
3 at least one respective rough preliminary value of the at least one unknown coefficient
4 and to compare the test surface profile and the approximate profile prediction
5 incorporating the at least one changed value.

1 28. The method of claim 24 wherein the means for generating an indicator of difference
2 between the test surface profile and the approximate profile prediction employs a
3 multidimensional nonlinear least-squares technique.

1 *29.* The method of claim 1 further comprising the step of applying a plasma process to
2 the process substrate, the plasma process being defined by the respective process value of
3 the at least one input variable.